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Final Report for Period: 09/2003 - 08/2006
Submitted on: 12/30/2005
Principal Investigator: Wu, C. F. Jeff
Award ID: 0426382
Organization: GA Tech Res Corp - GIT
Title:
Design and Analysis of Experiments for Screening, Optimization and Robustness

Project Participants

Senior Personnel

Name: Wu, C. F. Jeff
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Name: Joseph, Roshan
Worked for more than 160 Hours: No
Contribution to Project:

Name: Xu, Hongquan
Worked for more than 160 Hours: No
Contribution to Project:

Name: Qu, Xianggui
Worked for more than 160 Hours: No
Contribution to Project:

Name: Mandal, A.
Worked for more than 160 Hours: No
Contribution to Project:

Name: Qian, Z.
Worked for more than 160 Hours: No
Contribution to Project:

Undergraduate Student

Technician, Programmer

Other Participant

Name: Mukherjee, R.
Worked for more than 160 Hours: No
Contribution to Project:
Dr. Mukherjee visited Michigan in March of 2001 to start working with the PI on the book writing project. A draft of 50 pages have been written.

Name: Berube, Julie

Worked for more than 160 Hours: No
Contribution to Project:

Name: Hou, Xiaoli
Worked for more than 160 Hours: No
Contribution to Project:

Name: Cheng, Shaowei
Worked for more than 160 Hours: No
Contribution to Project:

Name: Wu, Huaiqing
Worked for more than 160 Hours: No
Contribution to Project:

Name: Zhu, Yu
Worked for more than 160 Hours: No
Contribution to Project:
Research collaborator, not receiving support

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Drs. Berube, Hou, Zhu and Cheng collaborated with me on the papers as listed in the publication section. They did not receive support as they have graduated. H. Wu is an Assistant Professor at Iowa State. He did not receive support.

Activities and Findings

Research and Education Activities:
Eleven papers have appeared in high quality journals. Five students were partially supported by the grant. Four have completed their Ph.D. degrees and hold tenure track assistant professorship. The fifth one will graduate in spring of 2006. Our work have been presented in various national and international meetings.

Findings:
Two papers on parameter design: one(Berube-Wu) on the performance of the much publicized signal-to-noise ratio by Taguchi; another (Hou-Wu)on the determination of robust settings in terms of some graphical plots. The first provides a comprehensive study of the performance of Taguchi's SN ratio, which has generated a great deal of controversies since 1985. Our study gives some definitive conclusion on its restrictiveness and some alternative measures are shown to be better. The second gives a theoretical connection between the much used control-by-noise interaction plots and the prediction variance model. The Mukerjee-Wu paper develops a new technique using projective geometry to find minimum aberration designs with mixed levels, which enables us to identify some new and useful designs to have minimum aberration. The Cheng-Wu paper appeared as a discussion paper (with 8 discussions) in Statistica Sinica as part of its millennium series. It has the potential to open up a new direction of research for response surface methodology and nonregular designs. The Cheng-Wu paper on blocking develops a new set of criteria for finding optimal blocking schemes for 2- and 3-level fractional factorial designs. The Wu-Wu paper

gives the first theory to prove the maxC2 property of designs, many but not all of which are minimum aberration designs. It provides the first link between the MA criterion and the clear two-factor interaction criterion. The two papers with Joseph address modeling and optimization problems for dynamic parameter design with multiple targets and for operating window experiments. The latter was proposed by Don Clausing at Xerox and has been used in industries. Our paper is the fist one to give it a rigorous foundation and extensions of strategies in system optimization and data analysis. Both have appeared in 2002. The Huwang-Wu-Yen paper was the first one to systematically investigates the pros and cons of the idle column technique, which was proposed by Taguchi and widely used in industries but little understood. The Wu-Zhu paper studied the problem of how to select a single array, instead of the cross array, for running parameter design experiments and suggested some criteria for optimal selection of single arrays.

Training and Development:

The following students have been partially supported on the project:
Hongquan Xu, Xianggui Qu, Roshan Joseph, A. Mandal, Z. Qian. Four have completed their Ph.D. degrees. Xu is a tenure track assistant professor at UCLA. Qu is a tenure track assistant professor at Oakland University. Joseph is a tenure track assistant professor at School of Industrial and Systems Engineering, Georgia Tech. He won the NSF Career Award in 2004. Mandal is a tenure track assistant professor at U. of Georgia. Qian will graduate in spring of 2006 and is actively looking for an academic job.

Outreach Activities:

I have given a short course on robust parameter design during the JSM in 2002 August based on the book I wrote with Hamada. Some results in the book were based on research funded by a previous NSF grant.

Journal Publications

J. Berube and C.F.J. Wu, "Signal-to-noise ratio and related measures in parameter design optimization: an overview.", Sankhya, Series B, p. 417, vol. 62, (2000). Published

R. Mukherjee and C.F.J. Wu, "Minimum aberration designs for mixed factorials in terms of their complementary sets", Statistica Sinica, p. 225, vol. 11, (2001). Published

X.Hou and C.F.J.Wu, "On the determination of robust factor settings in parameter design experiments", Statistics and Probability Letters, p. 137, vol. 54, (2001). Published

S.W.Cheng and C.F.J.Wu, "Factor screening and response surface exploration (with discussion)", Statistica Sinica, p. 553, vol. 11, (2001). Published

S.W.Cheng and C.F.J.Wu, "Choice of optimal blocking schemes in two-level and three-level designs", Technometrics, p. 269, vol. 44, (2002). Published

V.R.Joseph and C.F.J.Wu, "Operating window experiments: a novel approach to quality and reliability improvement", J. Quality Technology, p. 345, vol. 34, (2002). Published

V.R.Jospeh and C.F.J.Wu, "Robust parameter design of multiple target systems", Technometrics, p. 338, vol. 44, (2002). Published

L.Huwang, C.F.J.Wu, C.H.Yen, "The idle column method: construction, properties and comparisons", Technometrics, p. 347, vol. 44, (2002). Published

C.F.J.Wu and Yu Zhu, "Optimal selection of single arrays for parameter design experiments", Statistica Sinica, p. 1179, vol. 13, (2003). Published

Huaiqing Wu and C.F.J.Wu, "Clear two-factor interactions and minimum aberration", Annals of Statistics, p. 1496, vol. 30, (2002). Published

H. Xu, S.W.Cheng and C.F.J. Wu, "Optimal projective three-level designs for factor screening and interaction detection", Technometrics, p. 280, vol. 46, (2004). Published

Books or Other One-time Publications

R. Mukherjee and C.F.J. Wu, "A Modern Theory of Factorial Designs", (2006). Book, Accepted
Bibliography: Springer

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

These papers make collective contributions to the theory and methodology of experimental design. Four of them provide some new insight on the design and analysis of data from parameter design experiments and optimization. The work on operating window experiments is the first research to provide understanding and pave a rigorous foundation for this industrial practice. Four papers make some fundamental contributions to the theory of minimum aberration designs for more complex problems (mixed levels, with blocking structure, robust parameter design, and connections with clear two-factor interactions). The discussion paper has the potential to be a pathbreaking paper as it is the first to point out that factor screening and response surface exploration can be done in one experiment and using one design. This is a marked deviation from the classical paradigms due to George Box. Another paper gives the first study of an intriguing technique proposed by Taguchi called 'idle columns'. It is the first general construction method for this technique.

The PI was elected to the National Academy of Engineering in 2004 for his work in quality engineering and design of industrial experiments, some of which were funded by NSF in the past 27 years. He has also received the 2005 Jerome Sacks Award for outstanding cross-disciplinary research from the National Institute of Statistical Science for his life-long work on the interface between statistics and engineering.

Contributions to Other Disciplines:

Because parameter design, minimum aberration designs and response surface methodolgoy are widely used in product and process development and practiced in industries, our research results have the potential to be adopted and thus contributes toward such improvement. The PI has been invited to speak at many national and international meetings and give short courses based on his book with Hamada. The work can reach its users through various channels.

Contributions to Human Resource Development:

Five Ph.D. students are supported on the project. Details in the section on training. Four are tenure track assistant professors at research universities.

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Categories for which nothing is reported:

Organizational Partners

Any Web/Internet Site

Any Product

Contributions: To Any Resources for Research and Education

Contributions: To Any Beyond Science and Engineering